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ABSTRACT

In order to analyze the reading and comprehension of college students using a computer video terminal (CRT), a computer program was designed to present text material, time the performance, and compute the rate of reading for each of 118 subjects. Specifically, the program sought to determine if reading and comprehension are affected by the CRT display format and whether rates of reading and comprehension vary with respect to the order of presentation of test passages. The reading rates of the students were tested using four sample passages selected from different periodicals. Immediately following the presentation of each passage, the students were presented with five recall questions one at a time. Findings suggest that reading and comprehension are not appreciably affected by the CRT display format. Further, the order of presentation of reading test passages appeared to produce no significant differences in student performance. (FL)

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Empirical Study of Reading and Comprehension as a Function of CRT Display

Todd Hoover

INTRODUCTION:

During the past few years, considerable attention has been given to the use of computers for instruction. Their use has varied extensively; however, one important function has been to use the computer to present and control reading materials. While many pieces of research have reported the experimental effectiveness of computers in instruction, no literature has reported the effects of the CRT (television-like terminal) character display relative to reading performance and comprehension.

Follman, et. al. (1972), reported research on the effects of type-face (typewriter) as a function of rate and comprehension as well as other dimensions. The results suggested that no significant differences were found to be systematically related to type-face. However, there isn't any literature reporting the effects of CRT type-face (font) as a function of rate and comprehension.

The present study attempts to analyze the reading and comprehension performance of college students using the CRT. A computer program was designed to present text material, time the performance, and compute the rate of reading. Reading rates were tested using four (4) different sample passages selected from different periodicals. Immediately following the presentation of each passage, five (5) recall questions were presented one at a time. That is, after the subject answered a question, the next question was presented.

METHODS AND PROCEDURES

A computer program was written by the author using the BASIC compiler and prepared so that the S's were presented with one practice session followed by three (3) additional text passages. Each passage was approximately 340 words in length. Following the presentation of each passage, five (5) recall questions were presented. At the conclusion of the experiment, three (3) questions were

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asked to obtain general information about each S. The questions were as follows: Indicate the number of hours enrolled during the present term, estimate the average number of hours studied each week, and estimate the average number of hours worked.

A significant advantage of using a computer is the ability to control stimulus materials. In the typical reading test, an individual is given a passage, told to begin reading, and asked to stop after one minute. The rate of reading is then calculated. By contrast, the computer program designed for this study presented the passage which was broken into two or three pages depending on the treatment group. The computer system presented each page at a rate of 9600 Baud. Using the 9600 Baud rate, one page of text material is presented almost instantly. The system waits, counting time, until the S presses the return key on the terminal to advance to the next page. This is repeated again until the reading passage is completed.

The program was also designed to assess the time required for the S to press the key. The derived constant was deducted from the time to read each page. Therefore, it was assumed that the system could calculate a more precise estimate of reading rate.

Another feature of using the computer is, of course, the ability to calculate and store information. Hence, the program was designed to calculate all reading scores and store the information on a master file. Similarly, the program was designed to present each test question and store the result of each question along with the computed comprehension rate. These advantages constituted a major labor-saving device. Several students hired and trained to operate the program using a standardized procedure. These students eliminated the need for professional personnel to administer the test.

CRT AND COMPUTER

A new SOROC Model 120 terminal was used for the research. The terminal is representative of the industry incorporating many of the standards used by the majority of manufacturers. The screen is approximately 12 inches measured diagonally with each character composed by a 5 by 7 dot matrix using P4 phosphor. Twenty-four (24) lines with eighty (80) columns are vailable for displaying information. The letters are generated as a slight bluish-white image on a dark background. Light from overhead florescent fixtures was subdued with the use of a large screen eliminating any direct light falling onto the screen of the CRT. This was done to minimize the distraction of light relecting from the surface of the screen.

One of the difficulties in using the CRT is the closeness of printed lines relative to each other. On the CRT, the spacing between lines is minimal, at best, such that it is difficult for the eyes to maintain proper tracking without careful concentration. While the characters are printed approximately 3/16 of an inch in height, only 1/16 of an inch spacing is placed between lines.

A disadvantage of the SOROC 120 terminal (as well as most other terminals) is the physical appearance of small case letters. Each is formed in an unnatural manner bearing no similarity to the normally printed small case characters. For example, the letters "p", "g", "y", "q" and "j" are shifted up to allow formation within the 5 by 7 dot matrix. This format is highly distracting; thus the experimental treatment utilized only upper case letters.

The computer consisted of a new Harris S210 system which is featured as a time-sharing system. To assess the impact of system utilization, a small program was parepared to check the effect of the internal clock as a function of system loading. The results showed that the system worked reliably regardless of the number of users connected to the Harris. The CRT was hard-wired to the Harris to permit rapid display capability.

TEST QUESTIONS:

A battery of test items was prepared including many possible questions from each reading passage. The battery was presented to fifty=four (54) college students who had no prior experience with the selected reading passages use in the experiment. The test items were recall in character.

Following the administration of the test battery, each item was analyzed using norm-referenced test item analysis procedures. Since each item was composed of the stem and four (4) foils, only those items passed by 25% or fewer students was used in the experiment. Hence, it could reasonably be expected that performance on the test was a function of chance unless influenced by the experimental treatments.

READING SELECTIONS:

Four (4) reading passages were selected with one serving as a practice session. The passages were selected from four (4) separate periodicals judged by content specialists to be representative of materials college students might read in lower division college courses. Periodical literature was selected instead of passage from text books because of possible contamination by students having read the passages as a result of classroom assignments.

The practice passage was 365 words in length taken from the November 1977, issue of Harper's (Sorrention). This was suggested as being fairly typical of the type of reading a student does in a literature class. The second passage was 339 words in length taken from the November 1977, issue of Scientific American (Groth). Again, it was suggested as being fairly typical of the type of reading for students enrolled in a science course. The third passage was excerpted from October 1977, issue of Psychology Today (Archer). The length of the passage was 334 words. The final passage was from the October 1977, issue of Money (Boroson) and consisted of 336 words.

The Harper's passage was taken from a short, fictional story concerning the relationship between a man and his wife and the man's frustration with living. The article from Scientific American discussed the origin of galaxies and their behavior. The Money article spoke of new trends in mortgages for homes owners, and the final passage was about body language (Psychology Today).

ADMINISTRATION OF TEST:

As indicated previously, a small number of student research assistants was employed to administer the experimental reading tests. Each was trained to operate the computer and program with the program being designed for simplicity of operation. The research assistants were trained to use a standard procedure for introducing the experiment. Essentially, the assistant read a prepared statement to the S identifying what he was to do. After the explanation, the assistant began the program. The program presented the practice situation and practice test questions. The S was given one additional opportunity to ask questions. After this point, the S advanced the program to the first experimental reading passage. The assistant did nothing else until the conclusion of the activity.

When completed, the program then presented to the S a brief summary of his reading performances. S's were scheduled from as early as 9:00 a.m. to as late as 8:30 p.m. each day. The scheduling for test periods allowed thirty (3) minute periods throughout the day; therefore, no more than one S was sitting at the terminal at a time. The computer program randomly assigned S's to treatment groups due to the nature of the experimental population.

EXPERIMENTAL POPULATION:

All S's were volunteers whose participation was solicited by the E visiting various classes on the college campus. Included in these were education and science classes. Generally, about fifty (50) percent of the members of the various classes actually volunteered. Approximately sixty (60) percent of those volunteering actually

appeared for their appointments. Anticipating this difficulty, the E designed the computer program so that the S's were assigned to treatment groups when they actually appeared. This was achieved by using the random number generator of the computer. 118 S's actually participated in the study.

EXPERIMENTAL HYPOTHESES:

As indicated during the introduction, conserable interest is being directed toward the use of computers in education for a variety of purpose. Included among these is computer assisted instruction which frequently requires the student to read instructional materials directly from a CRT rather than from a text book. Hence, concern was raised because of the display characteristics of contemporary CRT terminals. Too frequently, the lines of display are "packed" rather tightly. That is, the characters are uniformly displayed and are approximately 3/16th inch in height with about 1/16th of an inch separating lines. It was felt that too little space separates the lines resulting in poor student performance.

One of the variables being examines with this study consisted of comparing the reading and comprehension performances of S's exposes to "packed" line display versus the following display: presenting the text every other line, thereby creating a display which was felt to be easier to read. However, the second display mode was also unnatural as it had considerably greater space between lines than normal. The first of two hypotheses is presented below:

STATISTICAL HYPOTHESIS I: There will be no statistical differences between tests displayed in a "packed" format versus alternate line as measured by reading rates and comprehension measures.

A second experimental issue was whether or not rates of reading and comprehension measures vary with respect to order of presented test passages. The three test passages were presented in different orders so that all possible permutations were presented. Table 1 provides the order of passages which served as the basis

for Statistical Hypothesis II

STATISTICAL HYPOTHESIS II: There will be no statistically significant difference among ordered presentations as measured by reading rate and comprehension.

1 = Money passage 2 = Psychology Today passage 3 = Scientific American passage

Order

Treatment Group: 1	2	3	4	5	6
1	2	3	1	2	3
2	3	1	3	1	2
3	1	2	2	3	1

TABLE I: Permutations Table

EXPERIMENTAL DESIGN AND ANALYSIS OF DATA:

This study utilized a variation of design No. 6 from Campbell and Stanley (1963) which takes the general form of:

R X O
R O

where: R = randomization
X = treatment
O = Post-test

Ideally, there should be a control group. In the present study, the pre-testing of the test assumed the control group effect since all selected items were passed by 25% or fewer persons. Of course, this design has some inherent difficulties; however, because of the nature of the experiment, it was difficult to correct

Some of the limitations include the following:

(A) Interaction of subject and treatment
(B) Reactive arrangement with respect to the test.

The analysis consisted of using the two by six analysis of variance approach which appears as follows:

		Text Order						
		1	2	3	4	5	6	
Type of Display	1	6*	4	4	11	12	4	41
	2	14	8	11	13	15	16	77
		20	12	15	24	27	20	118

*Cell size

The SIPS package (Statistical Interactive Program System) was utilized with the Harris computer for data analysis. To analyze the data effectively, it was necessary to break the data into respective passages. More specifically, the results for each passage were analyzed consistent with the above scheme.

RESULTS OF ANALYSIS:

The results of the data analysis are displayed in Table 2. In general, the results demonstrate that there were no statistically significant effects due to type of display or to the order of the passage presentation. Hence, the null are confirmed for both statistical hypothesis. Therefore, it is concluded that no real differences in reading rates or comprehension are attributable to the two different types of display and to the other of test material presentation.

MONEY Passage		PSYCHOLOGY TODAY Passage		SCIENTIFIC AMERICAN Passage	
RATE:		RATE:		RATE:	
Main effects		Main effects		Main effects	
Order**	NSD*	Order	NSD	Order	NSD
Display***	NSD	Display	NSD	Display	NSD
COMPREHENSION:		COMPREHENSION:		COMPREHENSION:	
Main effects		Main effects		Main effects	
Order	NSD	Order	NSD	Order	NSD
Display	NSD	Display	NSD	Display	NSD

TABLE 2: Analysis of Variance Results

NSD = No Significant Difference.

Order refers to the relative order of the passage with respect to other passages.

Display refers to "packed" or alternate line display.

As a check on the homogeneity of variance, data from the three questions following the conclusion of the experiment were analyzed. Using the same design for the analysis, the following results (Table 3) were obtained;

Question: Indicate the number of hours enrolled	
Main effects	
Order	NSD
Display	NSD
Question: Estimate the number of hours studied each week on the average--	
Main effects	
Order	NSD
Display	NSD
Question: Estimate the number of hours worked each week on the average--	
Main effects	
Order	NSD
Display	NSD

TABLE 3: ANOVA for general questions

Apparently, the populations within each of the cells are distributed normally. Therefore, it is concluded that the results of the experiment are not due to spurious data.

Additional statistics worth noting from the experiment included the grandmeans for the different reading selections. Table 4 includes these results along with the grandmeans for hours enrolled, hours studied, and hours worked.

	RATE (words per minute)	COMPREHENSION (percent correct)
Money passage	187.31	43.38%
Psychology Today passage	226.74	40.91%
Scientific American passage	184.98	60.11%

	MEAN	STANDARD DEVIATION
Hours enrolled	14.325	3.635
Hours studied per week	15.272	9.667
Hours worked per week	13.195	13.805
Total encumbered hours per week average	42.792	N - 118

TABLE 4: Grandmeans for readings and general questions

DISCUSSION:

Apparently, the CRT display format as defined in this article has little bearing on the performance of volunteer experimental subjects (college students) in terms of their reading rates and levels of comprehension. Furthermore, the order of presentation, i.e., passage one, two, three; or, two, one, three, etc., has little effect on performance.

Many of the S's who were exposed to the "packed" display frequently commented that reading the materials was difficult. However, neither their reading rate nor comprehension suffered as evidenced by lack of statistically significant differences. Therefore, one can conclude that a computer program can be designed either way; that is, designed so that each line produces displayed text or to display the text on alternate lines.

It is unsafe to generalize too much because of the nature of population except to say that college students who volunteer for reading tasks will perform similarly. On the other hand, students who generally do not volunteer for such activities may perform differently. An interesting question is the relationship of variously skilled readers and their performances using a computerized reading test. For example, what kind of performances will ordinarily poor readers have when exposed to text material presented on a CRT using packed or alternate line presentation?

Clearly, these types of questions need to be answered for two reasons. First, it is necessary to determine reading performances of students so that appropriate kinds of display can be developed. Second, the computer industry needs evidence to justify developing hardware (CRT terminals) which more closely resemble standard typefaces.

While the experimenter anticipated significant results between the "packed" presentation and alternate line presentation, a possible reason for the lack of significance may be due to the S's ability to adapt their eyes to the type as well as increase their concentration when needed. Hence, they did not experience any

performance difficulty. As indicated earlier, however, many S's indicated that they had ifficulty reading the "packed" display.

Comprehension was rather low, but this is largely attributed to the straight recall questions used. This meant that students needed to remember greater amounts of detail than perhaps they ordinarily would. However, reading the passages did substantively improve the ability of the S's to more corrrectly answer the questions since the mean gain was 23.13% above chance.

The cost for each test is relatively small since connect time is about twenty (20) minutes and CPU is approximately five (5) seconds. It is estimated that each test administration (connect time, CPU time, and clerical help) approaches one dollar. Therefore, it appears that a test of this sort is relatively inexpensive and ideal for certain situations requiring specific information about reading performance. Diagnostic tests, small group tests, criterion referenced tests (those for specific reading areas--science, literature, etc.) to name only a few applications. By contrast, cost efficiency for large group administration is unclear. This is due to the need for many terminals over an extended period of time.

One final comment is associated with the relative relationship among hours in class, hours studied and hours worked. One of the general rules of thumb for college is that a student should plan to spend two hours of study time for each hour of classroom time. Since the average number of hours enrolled by the population used for this study equals slightly more than fourteen (14), the rule would dictate that the student should spend twenty-eight (28) hours studying each week, or, a 42 hour work week. However, on the average, this rule appears to have changed. Apparently, the new rule is that students study one hour for each hour enrolled in class. It is also interesting to note that the students are spending about 13 hours working each week at various jobs. The students are still spending about 42 hours engaged in work related tasks (14 hours + 15 hours + 13 hours = 42 hours) but less time studying and more time working for an income.

In summary, reading and comprehension are not appreciably effected by using "packed" text display versus alternate line display. Also, the order of reading test materials appear to produce no significant differences.

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